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BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
FOREST INSECT INVESTIGATIONS

THE FOREST INSECT HAZARD INVENTORY OF EASTSIDE FOREST AREAS:
PRELIMINARY REPORT ON METHODS AND THEIR APPLICATION.

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by
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Berkeley, California
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THE FOREST INSECT HAZARD INVENTORY OF EASTSIDE FOREST AREAS:
PRELIMINARY REPORT ON METHODS AND THEIR APPLICATION.

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THE FOREST INSECT HAZARD INVENTORY OF EASTSIDE FOREST AREAS:
PRELIMINARY REPORT ON METHODS AND THEIR APPLICATION.

Each timber owner is vitally interested in the ways and means for securing the greatest returns on his investment in stumpage. Each private or public administrator of forest lands is concerned with the problem of maintaining the forest capital under his direction in the best possible condition for production of more capital; for liquidation when favorable economic conditions occur, and for production of the most valuable materials his land can produce. However, those objectives, particularly on the more than two million acres in eastside forests, cannot continue to be realized merely by letting the timber grow and cutting it when mature or when the opportunities for conversion at the best prices present themselves.

During the past fifteen years, forest insects have been very active in destroying the merchantable values of the uneven aged eastside stands in California. They have caused destruction of large amounts of forest capital before the mature crop could be harvested. An entomological complex in which several species of barkbeetles and cambium borers are concerned, is the cause of most of the loss in pine timber. This complex changes in character from year to year. It has different character and potentialities in different types of stands. It is decidedly influenced by physical environmental factors.

In eastside uneven aged virgin stands and over large areas embracing many ownerships and administrations, the forest insect problem is of primary importance. It is not for an individual owner or an individual forest administrator to attack from the standpoint of its effects on his relatively small holdings alone. It is a larger problem that must be tackled on a much more comprehensive basis. It is one that varies greatly even within the areas in which the entomological factors are important.

The reserves that are left by the various economic and silvicultural systems of utilization are dying off in many areas and cannot be listed as assets at the close of the long cutting cycle that is an essential element of present forest utilization practices. Efforts to offset this loss and the loss preceding logging of virgin stands are tending towards the use of shorter cutting cycles and lighter cuts. These methods should be applied with an intelligent understanding of the potentialities of forest insect infestations in the areas to be managed. If that is done it may be possible to reduce forest insect activity and to prevent economic losses following treatment. The faster coverage of large areas that will accompany the lighter cut should allow better utilization of the forest capital that is now ready for harvest.

The Bureau of Entomology and Plant Quarantine recognizes its responsibility to aid in discovering what can be done to meet the forest

insect problem. One phase of its job is to provide the basis on which the timber owner or administrator may determine the action he must take to lessen destruction of values by forest insects. That basis may be furnished by a classification of timbered areas according to the potential hazard from insect outbreaks. The long experience with infestations that has been built up by the Bureau in its contact with and research on forest insects, has resulted in several conclusions that can be used in developing that classification. These conclusions are as follows:

1. In the large timbered areas of the California eastside subregion, great variation exists from year to year in the intensity of forest insect activity and in the resultant loss.

2. Although the relative intensity of infestations in different large areas or in parts of those areas may vary greatly in one or for a few years, over a sufficient period of time there is a fairly constant relation between the losses in those different areas or parts of areas.

3. Areas in which past losses have been heavy will be those in which future losses can be expected to be heavy providing (a) the past losses have been associated with or caused by general environmental levels and not by accidental disturbances or (b) the losses or other factors have not caused radical modification of the stand structure.

The above conclusions provide the basis for expecting that, by considering the past loss record of forest areas one can determine the hazard, under comparable stand conditions, from future insect losses. Also it can be expected that consideration of the past loss records of different areas having comparable conditions, but subject to different intensities of environmental pressure, will provide a means for determining the relative hazard from insect losses in those areas.

These hazard ratings should provide a measure for determining the extent to which management and utilization must take the entomological factors into consideration. They also indicate, in general, the types of control action that may be the more effective in combatting infestations.

These expectations are based on a well-founded biological theory that the amount of insect activity and injury to host plants, is the result of the balance of favorable and unfavorable environmental factors affecting insects and hosts. The determination of this basic relation, in terms of potential hazard to stands from forest insect attack, is the objective of the Forest Insect Hazard Inventory Project of this laboratory. The project is concerned only with the hazard in eastside uneven aged stands that is due to fundamental environmental differences. Its results may be applied to large areas only when the factors affecting the forest insect infestations act in a similar manner but at different

intensities and when stand conditions are comparable. Correction factors must be determined and applied for different environmental trends and stand conditions.

This project is a part of a long term attack on a condition the lumber industry will have to meet. A survey of this type is necessary to supply the basis for a sustained program dealing with protection, harvesting and management of eastside forests.

OBJECTIVES OF THE 1936 FIELD WORK

The observations of many years form the basis for concluding that there is a fairly constant relation between the hazard from insect caused losses in different areas bearing uneven aged stands. The objectives of the 1936 field work therefore were to determine:

1. If these differences were essentially local or if they were widespread and applied to broad zones or areas.
2. How these differences could be measured and what gross environmental factors should be considered.

It also was hoped that the data secured from this project, when added to the Bureau's experience, would furnish the basis for formulating a hazard classification and develop a method of applying that classification in the field.

SAMPLE AREAS

The area originally selected for the work is situated in T. 32 and 33 N., R. 10 E., M. D. M. in the northeastern part of the Lassen National Forest. The stand had been typed chiefly as ponderosa pine although jeffrey pine, white fir and incense cedar occur in varying amounts. Study of cores taken from green trees showed that the general trend of diameter growth had been upward from 1883 to 1907. In 1907 the trend changed and since that time there has been a sharp decline.

The site index is III in the northwestern portion of the area becoming lower towards the south and east. There relatively light stands of a marginal type have a site index of V. The average site index for most of the area is IV. The elevation ranges from 5250 ft. near the shores of Eagle Lake to 6800 ft. at Dow Butte. Precipitation probably is between 15 and 20 inches annually. The country consists chiefly of rolling slopes having an easterly drop in elevation and, in general, a southerly exposure. Lava outcrops are common throughout the area and some steep lava rims and slopes occur, particularly on Cave Mountain and Dow Butte. The stand as reconstructed from the work, averaged 18,780 b.m. per acre in 1926 on the 15,510 acres that were sampled.

Before the results of the 1936 study can be considered, it is necessary first to see if there are measurable differences in the past loss records that are to be used as a basis for estimates of future harvest. All five sample areas selected for measurement were known to have had different infestation histories and were considered to have different infestation potentials. The differences

RESULTS

All information was secured on a 40 acre basis. However, it has been grouped on a quarter section basis in the final analysis as the smaller unit gave no more certain quantitative results. Notes were taken on topography, site, ground cover, reproduction, general stand structure and thinning. Strips were classified according to loss, susceptibility classification. In addition to stand and loss figures, the green trees on the

period of loss would be covered as a longer period is desirable. With similar records from green trees. It had been hoped that a longer cross checking the growth record from chips and increment cores of snags down but sound snags to 1926. These dates were determined carefully by were failed. Current losses dated to 1934, standing snags to 1931 and was found that a ten year loss period was covered by the snags that trees, furnished the basis for estimating the 1926 stand figures. It from these classifications of loss, when added to the cruise of living by diameter and number of logs. The sum of volume figures derived loss, standing pine snags and down but sound pine snags were failed. It was made by using standard methods. In addition, all current pine a five percent cruise of all living trees over twelve inches

METHODS

Location	National Forest	Area Sampled (acres)	Site	Timber	Avg. B.M.	Per Acre	In 1926
Near Hogard Butte	lassen	1,280	II-III	Y	40,040		
Black Butte near Round Mtn.	Modoc	820	II-III	Y-S-10	27,610		
Lava Beds near Round Mtn.	Modoc	680	III-IV	Y	18,900		
Badger Township (Central and North parts)	Modoc	1,760	IV	Y	19,080		

A preliminary analysis of the data secured from the above sample areas showed the desirability of securing samples from other areas subject to other environmental conditions. Accordingly the following areas were sampled.

in past losses, as measured by the methods used in the Hazard Inventory Project showed that there were marked differences in the records from the sample areas. There were differences not only in the average amount of past loss but also in the manner in which the loss occurred. These differences are shown by the following data and observations:

<u>Area</u>	<u>Estimate of Hazard</u>	<u>% of loss</u>	<u>Ratio of current to old loss.</u>
Hogard Butte	Hazard low in spite of marked overmaturity of pine stand	14.1	Average current loss
Buck Butte	Hazard markedly lower than surrounding stands.	19.9	Very low current loss
Eagle Lake	Hazard relatively high, some parts of area marginal	25.9	Current loss high
Lava Beds	Hazard lower than much of Modoc area but much higher than adjacent Buck Butte area in spite of younger and thriftier stand	31.2	Current loss fairly low
Badger	Hazard high, approaching that of a marginal stand	42.4	Current loss about average

Differences in amount of cruised loss fall in line with the estimates an experienced entomologist would make as well as with such plot records as are available for comparison. It is important to note that the amount of current loss, in relation to the old loss, has varied from very low to average in the Modoc samples. In the Lassen samples it varied from average to high.

Objective No. 1. Are these differences essentially local or are they widespread and applicable to broad zones or large areas?

The two Lassen samples are essentially parts of a very large area in which the general trends of infestations have been much the same. The same thing may be said of the three Modoc samples. Losses have been higher on the Modoc areas than on the Lassen samples. In addition there has, in comparison with the Lassen areas, been much less recent loss. In other words, and on a very broad basis, it can be said that there is a blanket effect of environment or of insect activity that causes differences in loss over large areas and on an extensive scale.

However, within these large areas, marked differences in parts of them are noticeable. They are not only measurable, as can be seen in the data secured from the several sample areas, but they also appear to be significant of primary differences in hazard and environment. Differentiation of hazard on the basis of such areas still remains on a fairly broad area basis.

Within one of these fairly large areas, such as the Eagle Lake sample of 15,510 acres, intensive study has shown that there are marked and very local variations. Although the stand, topography and gross measurable indices of environment show great variation, and in spite of the fact that losses ranged from 3.4 to 52.9 percent of the stand, results for the greater portion of the area showed surprisingly little variation. Over 70 percent of the area suffered losses of between 15 and 35 percent of the stand. The distribution curve (fig. 1) is normal and appears to be a sample of a fairly homogeneous field. It is believed that this condition is primarily the result of entomological forces that have been built up by the environment but which operate at such times and in such a manner as to offset the marked local differences. In other areas, as well as in the Eagle Lake sample, this action has shown it to be impractical to take into consideration the very local variations in estimating hazard or in planning forest management. In particular this is of importance in planning forest management practices that provide for future production. Accordingly it is concluded:

1. It is possible to determine differences in loss and hazard for very local variations in environmental factors.
2. The results of these local variations, over a period of time, are offset to a great extent by the action of partially independent entomological forces.
3. This action makes the determination of hazard on the basis of local environmental differences unsatisfactory and uncertain.
4. Subregional differences in hazard are determinable but are on such a large scale as to be of very little use in application.
5. Fairly broad yet moderately specific segregations of environmental units of less than a subregional rank, but of greater than a local rank furnish the best basis for a practical classification of hazard.
6. These environmental units, in eastside forest areas, may vary in size from a few hundred to several thousand acres.

Objective No. 2. How can these differences be measured and what gross environmental factors should be considered?

The use of plot loss records that have been secured by annual cruises furnishes a good basis for determination of hazard. However, few areas can be adequately sampled by plots.

Cruising of old losses, as practiced on the Hazard Inventory Project, also supplies factual data of value. However, if cruises of sufficient intensity to give accurate data are used alone in rating hazard, the costs of the work would be excessive. This method, when smaller samples are taken, does furnish figures which are of considerable value in checking the results of other less expensive and more extensive methods.

The hazard of the sample areas used in this study was determined by an intensive cruise of old losses. However, as has already been pointed out, the hazard as determined from these figures agreed very well with estimates based on a knowledge of the infestation history of these areas. However, such general estimates, when based on survey alone, do not have any factual basis. Under some conditions it is probable that, due to certain infestation conditions, a distorted picture could be secured by that method. Visual methods, when checked by a fairly extensive quantitative survey of conditions should, however, be of sufficient accuracy to warrant confidence. The samples surveyed should be selected samples. They may be used to show the location of boundaries of areas having different hazard or in determining quantitatively the percent of losses in areas of nearly equal hazard. This survey work need not be intensive but could be the result of securing loss figures on selected strips.

The intensive work carried on in 1936 on the Eagle Lake sample area showed that entomological forces can counteract the effects of local but basic environmental differences. They also can result in losses of approximately equal amounts in areas having markedly different environments. The season's work showed that loss surveys of the type described in this report checked very closely with the estimates based on experience and supplied a factual basis for those estimates. Also the survey made it possible to assess the values of certain environmental factors so that they may be utilized in securing either qualitative or quantitative hazard ratings. These assessments are as follows:

Volume per acre: This factor appears to have little relation to the amount of loss. However, it may be possible, when the low susceptibility of the light stands is considered, that the formation of large groups of infested trees during recent peak infestations was prevented by that factor of density. The susceptibility indices of the four volume classes into which the quarter section units of the Eagle Lake sample were divided are as follows:

Volume - B.M. per acre

Susceptibility index*

0 - 10,000	.85
10 - 20,000	1.13
20 - 30,000	1.01
30 - 40,000	1.12

Timber type: The surprising feature of the data collected to show the possible relation of timber type and insect loss or hazard is that the stands in which incense cedar occurs proved to have the highest average loss, and the highest susceptibility index. Evidence indicated that losses were more even during the entire period or were less than the average during the years of peak infestations.ponderosa pine-white fir type was at the opposite end of the list. That type showed the least susceptibility, and the next to the lowest average loss. In addition, recent infestations were heavier than in any other type that could be segregated for study. In many of the units more than one type was present. The figures showing the relation of some timber types to loss are as follows:

Type	Susceptibility Index	Ave. percent of stand killed	Relation of current to older loss.
PP-IF	.68	21.4	1:4.3
PF	.72	19.8	1:5.0
JP	.84	23.3	1:5.6
PP-JP	1.01	25.6	1:6.4
PP-JP-IC	2.02	33.4	1:6.0

The figures in the column "Relation of current to older loss" are believed to show something of how the losses occurred in the different types. In the type found to have the least susceptibility, a greater portion of the total loss occurred during the past two years. Group killings were typical of infestations in that type during that period. It is apparent that the supposedly more resistant types suffered more than the less resistant during the years of peak infestations.

Site index: The site index is a general measure of environmental conditions and thus there should be some relation between site index and loss. Site III was found to have a susceptibility index of .93. The index for site IV was .83 and for site V, 1.27. The surprising thing about the susceptibility indices for the three sites represented in the sample is the relatively small spread between the indices for the markedly different conditions. It is probable that the

* Note - A susceptibility index of less than 1.00 indicates less than average hazard in comparison with the average for the entire sample. An index of more than 1.00 indicates a greater than average hazard.

manner in which the losses occurred, i.e., the importance of recent group losses on the better sites in relation to the total losses, is responsible for the lack of spread and the partial obscuring of the relation of site index and loss.

Exposure: The southerly exposures (Susceptibility index 1.05) are known to be much more susceptible to losses than the northerly (Susceptibility index .92). That relation is shown but the lack of spread again is noticeable.

Slope: Although the heaviest loss recorded on any quarter section unit in the Eagle Lake sample occurred on a flat area, the areas with no or little slope are, from experience, known to be generally less susceptible to insect depredations. The susceptibility index for flat areas was found to be .75. Slopes, particularly south slopes, are known to suffer relatively heavy losses and to be susceptible. The index for slopes was found to be 1.40. It also is known that ridge tops and points of ridges suffer the heaviest insect loss. This is borne out by the susceptibility index which, for ridges, was found to be 1.95. Apparently the factor of slope is very closely related to losses and hazard.

Ratio of current to older losses: It seems that we may explain the normal distribution of loss classes on the Eagle Lake sample area and the lack of spread in the loss figures by examining the ratio of current to older losses. A low ratio indicates that recent losses constitute a larger portion of the total loss and a high ratio indicates that they are a smaller part of the total.

On site III areas the average ratio was 1 (current loss) to 4.3 (older loss). On site IV the ratio was 1 to 6.0, and on site V it was 1 to 11.1. This information when added to that known of recent infestation trends may be summarized as follows:

1. Losses on the poorer sites, although averaging slightly higher than on the better sites for the ten year period, are more the result of fairly consistent occurrence of relatively heavy losses than of sudden outbreaks.

2. Losses on the better sites have been brought up to a point rather close to the average for the entire area and not far below losses on many poorer units of the area by recent outbreaks resulting in extremely heavy losses.

3. This condition seems to be the result of entomological factors, particularly those factors associated with the force of infestations in the group phase of a cycle.

4. The ratio of current to old loss seems to explain why the range of loss figures for 70 percent of the sample area was relatively small. It also seems to explain why the range of

susceptibility indices for type, and site and possibly for exposure varied much less than might be expected.

Tariff: All green trees were tallied according to Keen's susceptibility classes. It was found that too few trees were present in many of the classes over a large part of the area to provide a satisfactory basis for analysis. However, it is considered significant that, when the stands were classified according to Keen's Susceptibility Classification, nearly half the number of trees on each sample area were classified as having a greater than average susceptibility.

CONCLUSIONS

The 1936 field work on the Hazard Inventory Project has provided a basis for the following conclusions.

1. It seems possible to secure a quantitative estimate of hazard by measuring the past loss if that measurement includes those that have occurred over a relatively long period of time.
2. The relative hazard also can be determined, if one is experienced and has an intimate knowledge of past conditions, by a visual estimate that takes into consideration the loss and certain gross environmental indices.
3. A large sample, which is expensive to secure, is necessary if the first method is used.
4. Dependence on the visual estimate method is likely to lead to some error, particularly if the estimator has not had an intimate knowledge of past infestation conditions.
5. A combination of visual estimates and selected measured samples seems to be the more practical and satisfactory basis for securing a hazard rating.
6. An adequate quantitative and qualitative basis for rating hazard may be secured on a (1) general (subregional), (2) a fairly specific (environmental unit), or (3) a very specific (local environment) basis. The second unit of estimate seems to be best adapted for application in forest management practice.
7. Hazard estimates that are based on the losses of the past decade represent the effects of the most critical conditions that have been recorded. As a result, they are based on maximum losses which, in terms of the present uneven aged stands, indicate the minimum production that may be expected from an area.
8. The areas that have been sampled seem to fall into three or four classes of a larger natural hazard classification that contains five such classes.

9. This classification of hazard is based primarily on the amount of past loss and consideration of other factors such as site index, timber type, exposure and slope. It seems possible, on the basis of extensive experience with direct control, and limited experience with indirect control measures, to use the hazard rating of any given area in formulating forest insect control action. It also is possible that some elements of management of those areas can be based on the infestation potentials as shown by the hazard rating.

CLASSIFICATION OF HAZARD

A tentative classification of hazard, which applies to the uneven aged eastside pine stands of California has been developed from the work of the Hazard Inventory Project during the season of 1936. That tentative classification is as follows:

HAZARD RATING I. Areas in which losses usually are replaced by growth. Usually mixed conifer stands on better sites. Losses during the past decade estimated not to have been more than one percent in any year. Control recommendations: Direct methods may be necessary only as emergency measures at infrequent intervals. Indirect methods probably valuable as a management practice on a fairly long cutting cycle. A heavy reserve volume probably can be maintained without much danger. Note. Few, if any, class I areas occur under true eastside conditions.

HAZARD RATING II. Areas in which, over a critical period of environmental conditions, mature stands show less than about a 10 percent net depletion. Usually better quality pine or mixed conifer stands on good sites. Control recommendations: Direct control as an emergency measure during outbreaks. Removal of high risk trees advisable on a moderately short cutting cycle. Reserve stand that may be maintained - probably a thrifty mature and fairly heavy stand. Example - Bogard area (14.1% of stand gross loss) which may be a low Hazard III area.

HAZARD RATING III. Depletion during critical period of environmental conditions averaging less than twenty percent. Pine stands of average quality on intermediate sites. Control recommendations: Direct control, if used, must be nearly on a maintenance basis during adverse conditions. Immediate utilization of high risk trees advisable on a fairly intensive management basis that uses a short cutting cycle. Reserve of thrifty immature to thrifty mature trees should have an average density. Examples - Buck Butte (gross loss 19.9% of stand). Northwestern portion of Eagle Lake sample.

HAZARD RATING IV. Depletion during period of critical environmental conditions averaging up to 35 percent, usually less although predominantly overmature stands may have averaged somewhat higher during the past decade. Poor to average quality pine stands on poor to average sites.

Control recommendations: Direct control or control by utilization of infested trees only an emergency measure and not for general use. Indirect control advisable cutting high risk trees under intensive management and on a short cutting cycle, probably supplemented by salvage work in some cutover areas. Management plans must be projected to secure high utilization of present values and maintain a fairly light thrifty immature to mature reserve. Examples - Southern and eastern portions of Eagle Lake sample. Lava Beds sample (gross loss 31.2 percent of stand).

HAZARD RATING V. Losses during the past decade averaging over 35 percent, usually over 40 percent of stand if stand is predominantly overmature. Marginal and submarginal areas under critical environmental conditions during the past decade. Future production on a commercial basis questionable except under better conditions.

Control recommendations: Under recent infestation conditions control usually unsatisfactory. Immediate utilization advisable unless stand is taken out of production and present values left to insure reproduction and production under possible more favorable future environmental conditions. Examples - Extreme fringe of Eagle Lake sample. Badger sample approaching class V although part taken in class IV area (gross loss 42.4 percent of stand).

The loss figures given under each class in the above classification are hard to define exactly and cannot be applied for an indefinite period of time. The figures given apply only to conditions during the past decade. However, that decade has been the most critical period that has been recorded. Such a period will determine the long term production possibilities of stands. All production secured above that expectation cannot be justly expected except as a result of unpredictable future conditions.

It is possible that future consumers requirements will make possible the utilization of materials now considered of poor quality or as practically unmerchantable. It also is possible that future conditions will favor the establishment and production of satisfactory stands on areas now considered to be marginal. However, those things cannot be forecast. If such changes do take place, it seems reasonable to conclude that the relative production possibilities of areas in each Hazard Rating class will rise in proportion to its present position. Areas now listed under the higher hazard classes will become those of lower hazard while some of those in the lower classes will remain where they are or become grouped with those in the next lower. On the average, the same general relations of area to area should remain fairly constant.

RECOMMENDATIONS

The results of the 1936 field work on the Hazard Inventory Project are satisfactory enough to make advisable a test on a more extensive scale. Accordingly it is intended to continue the work

during the 1937 season in other portions of the Lassen and classify the hazard, secure the factual background and produce maps and figures showing areas and resources falling in the several classes represented.

Reconnaissance estimates, supplemented by selected samples to check the estimates are recommended for use on this work. More data should be secured on the susceptibility of areas on the basis of the present stand. This work is to be undertaken using both established systems of tree classification (Keen's and Dunning's). In addition, classification of individual trees on the diagnostic basis that has been developed in connection with the flathead studies will be used to determine if it can be used to supplement the loss figures in checking the reconnaissance estimates. These data may be of great value for although losses may be low during a short period of favorable years, the stands will continue to have a high hazard if a large number of the trees are weak and unhealthy.

FIG. I

DISTRIBUTION OF LOSSES

EAGLE LAKE SAMPLE AREA
LASSEN NATIONAL FOREST

